Health Risk Limits for Groundwater

Minnesota Rules

The Minnesota Department of Health has adopted permanent rules defining health risk limits for 120 contaminants that have been found in Minnesota groundwater.[1] This fact sheet explains the health, risk limits, how they were developed, and how they are used, and includes the table of Health Risk Limits.

Background

The 1989 Minnesota Groundwater Protection Act directed the Minnesota Department of Health (MDH) to develop health risk limits for substances found to degrade groundwater through groundwater quality monitoring.

> A health risk limit (HRL) is the concentration of a groundwater contaminant, or a mixture of contaminants, that can be safely consumed daily for a lifetime. A health risk limit is expressed as a concentration in micrograms per liter, or calculated as a "hazard index."

The MDH developed the health risk limits using scientific risk assessment methods and data. The HRLs are calculated using the same methodology as for the "recommended allowable limits" (RALs), which were advisory levels MDH used before the HRL rules were promulgated. The HRLs replace the RALs.

The HRLs reflect health effects data alone. They do not incorporate economic or technological factors such as treatment cost and treatment feasibility, as do federal drinking water standards, the Maximum Contaminant Levels (MCLs). Economic and technological factors, the protection of the environment, and the health of nonhuman species are considered in other groundwater protection regulations.

The health risk limit rules are unique in that they do not specify how health risk limits are to be applied. Groundwater and environmental protection programs in the state determine the uses for health risk limits.

Methods and Data Used to Calculate Health Risk Limits

Health risk limits were developed using risk assessment methods and toxicologic data from the U.S. Environmental Protection Agency (USEPA), which are used by most states. USEPA's risk assessment methods undergo extensive review by USEPA scientists and a public review process.

The USEPA uses different methods to calculate safe levels of exposure to substances or chemicals that are carcinogens (cause cancer) and substances or chemicals that are systemic toxicants (do not cause cancer). The difference arises from the USEPA's assumption that systemic toxicants have a threshold dose below which they do not cause adverse effects. By contrast, the USEPA assumes that any dose of a carcinogen above zero presents some risk of causing cancer. Following are explanations of how health risk assessment issues are addressed in the HRL rules.

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[1] Minnesota Rules Parts 4717.7100 to 4717.7800

1. Reference Doses and Slope Factors

The critical variable in the calculation of a health risk limit is the potency of the substance or chemical. The measure of potency for systemic toxicants is called the "reference dose" (RfD) and the measure of potency for carcinogens is called the "slope factor." The toxicologic data used to calculate reference doses and slope factors usually come from laboratory studies on animals. Human data from epidemiologic studies are used when available. The statute indicates that the Minnesota Department of Health use reference doses and slope factors published by the USEPA and determined to have undergone thorough scientific review.

The department obtained most of the reference doses and slope factors used to calculate the health risk limits from the USEPA's Integrated Risk Information System (IRIS). This is an electronic database containing health risk and regulatory information on over 500 chemicals. The USEPA acknowledges IRIS as the USEPA source for reference doses and slope factors that has undergone the most thorough and standardized scientific review.

2. Multiple Routes of Exposure

Calculation of a health risk limit is based on a standard adult ingestion rate of two liters of water per day. The calculation of health risk limits does not account for multiple routes of exposure to groundwater contaminants. Although skin absorption and inhalation are potentially important means of contact with groundwater contaminants, adequate models for assessing exposure through these pathways have not been developed. The USEPA maintains that exposure to drinking water contaminants from air or skin exposure is accounted for in the relative source contribution factor, which is used in calculating a health risk limit.

3. Contaminant Mixtures

Groundwater monitoring data may reveal the presence of more than one contaminant. Reference doses and slope factors listed on USEPA databases are usually calculated from studies of exposures to single chemicals. A mixture of chemicals, even if each chemical is present at a concentration below its health risk limit, may produce effects that would not be predicted based on exposure to each component of the mixture alone.

Sometimes a substance or chemical will act synergistically to increase the potency of another, as in the case of asbestos together with cigarette smoke. Other times the opposite may be true, with an antagonistic effect. Or there may be no interaction if the chemicals act independently. Finally, mixtures of chemicals may act as though they are equal to the sum of their individual doses. This is an additive effect.

From a public health perspective, it is preferable to overestimate the risk from additive or synergistic effects than to underestimate the risk lesser health effects. The USEPA guidelines for the health risk assessment of chemical mixtures involves evaluating the health effects and toxicology data on the mixture or a similar mixture. If data exist only for the components of the mixture, which is most commonly the case, the USEPA guidelines recommend using an additive model for predicting risk.

The USEPA Risk Assessment Guidelines recommend generating a separate hazard index for each group of chemicals defined by a common toxic endpoint. In accordance with the recommendations of both the USEPA and the National Research Council, all carcinogens fall under one toxic endpoint: cancer. The toxic endpoints for systemic toxicants are the affected organ or organ system. The same studies used by the USEPA to calculate the reference doses were used to identify the toxic endpoints for the systemic toxicants.

Data are not available on most mixtures, and much of what does exist come from experiments with doses higher than those normally associated with exposures from groundwater. The possible increase of adverse health effects from multiple chemicals warranted a provision for chemical mixtures in the health risk limits rules. The MDH fact sheet, "Health Risk Limits for Mixtures of Groundwater Contaminants" explains the mixtures provision and how to calculate a health risks for a mixture of groundwater contaminants.

4. Detection Limits

Some health risk limits are below a level that can be detected using current and readily available analytical methods. The protection of public health, not detection technology, drives the health risk limits.

5. Selection of Substances or Chemicals

As indicated in the Groundwater Protection Act, the selection of a substance or chemical for the health risk limits rules was based on two criteria: 1) detection in Minnesota groundwater; and 2) publication of a reference dose or slope factor on USEPA's IRIS database. The statute was revised to permit use of other USEPA databases if a chemical is not listed on IRIS, in which case the primary studies are carefully reviewed.

The Minnesota Pollution Control Agency (MPCA) provided the department with a list of chemicals and substances identified in Minnesota groundwater. This list was verified with the Minnesota Department of Agriculture and the Department of Health's section of Water Supply and Well Management.

Health risk limits were not developed for complex mixtures, such as gasoline, for which there is no reference dose or slope factor listed on IRIS. Instead, health risk limits were developed for the components of complex mixtures that have a reference dose or slope factor published on IRIS.

The 1989 Groundwater Protection Act specified the use of data from U.S. EPA's carcinogen assessment group, now EPA's Integrated Risk Information System (IRIS), to develop the HRLs. This posed a limitation on development of health risk limits for some contaminants in Minnesota groundwater that were both prevalent and of public health concern (such as trichloroethylene, or tetrachloroethylene). The statute was revised in 1994 to allow the Department to use a broader range of data sources for establishing a health risk limit.

6. Carcinogens and Systemic Toxicants

Two different methods were used for determining health risk limits: one for carcinogens, and one for systemic toxicants. "Carcinogen" refers to those substances or chemicals that have a common toxicologic endpoint: cancer. "Possible human carcinogens" are not included in the definition of "carcinogens" because of the limited evidence that they cause cancer. Systemic toxicants refer to substances or chemicals that USEPA lists as "noncarcinogens" or as "possible carcinogens."

How Health Risk Limits Are Used

The enabling legislation did not establish how the health risk limits would be applied in groundwater protection programs or services, except as criteria for Best Management Practices and Water Resource Protection Requirements. Uses of the HRLs are largely determined by state groundwater protection programs of the Minnesota Pollution Control Agency, Department of Agriculture, and Department of Health.

The Minnesota Department of Health uses health risk limits for several public health protection purposes.

1. **Advice for Private Wells.** Because private well drinking water supplies are not regulated for contamination, HRLs are used to evaluate contaminated wells and provide advice to consumers and well owners about the suitability of their water supply for consumption and other uses.

2. **Unregulated Contaminants in Public Water Supplies.** In instances where no federal drinking water standard exists for a contaminant in public water supplies, HRLs are used as criteria to evaluate options for reducing the community's exposure to the contaminant.

3. **Environmental Review.** The MDH uses health risk limits as criteria in environmental review projects. For example, monitoring data may be compared to HRLs to evaluate potential impacts of a project on public health.

4. **Site Assessment Criteria.** The MDH's Site Assessment and Consultation program uses HRLs as criteria to evaluate potential site impacts on public health, to make recommendations on monitoring and mitigation.

Revisions to the Health Risk Limits Rules

The rules include a provision for updating the health risk limits to keep them current. As more toxicologic studies are completed and evaluated, updated data on reference doses and cancer potency slope factors may be added to the USEPA databases. The USEPA may change an RfD or slope factor due to new scientific data. Sometimes the USEPA removes an RfD or slope factor while they consider new data. This provision for revising HRLs can permit MDH to add a health risk limit, change a health risk limit, or remove a health risk limit as data about a chemical change.

The **Table of Health Risk Limits for Groundwater and Toxicologic Endpoints** follows.

For further information about the health risk limits or for consultation in assessing health risks from groundwater contaminants, contact the Minnesota Department of Health at (612) 215-0880. To request this document in another format, call (612) 215-0700, TDD 612/215-0707, or toll-free 1 (800) 627-3529.

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Table of Health Risk Limits for Groundwater and Toxicologic Endpoints

Chemical or Substance	CAS RN	Health Risk Limit µg/L	Toxicologic Endpoint
Acenaphthene	83-32-9	400	liver
Acetone	67-64-1	700	kidney
Alachlor	15972-60-8	4	cancer
Aldicarb	116-06-3	1	nervous system
Allyl chloride (3 chloropropene)	107-05-1	30	nervous system
Anthracene	120-12-7	2000	----
Antimony	7440-36-0	6	----
Atrazine	1912-24-9	20	cardiovascular system
Barium	7440-39-3	2000	cardiovascular system
Benzene	71-43-2	10	cancer
Benzoic acid	65-85-0	30,000	----
Beryllium	7440-41-7	0.08	cancer
1,1-Biphenyl (Diphenyl)	92-52-4	300	kidney
Bis(chloroethyl)ether (BCME)	111-44-4	0.3	cancer
Bis(chloromethyl)ether (BCME)	542-88-1	0.002	cancer
Boron	7440-42-8	600	male reproductive system
Bromodichloromethane	75-27-4	6	cancer
Bromoform	75-25-2	40	cancer
Bromomethane (Methyl bromide)	74-83-9	10	stomach
n-Butanol	71-36-3	700	nervous system
Butyl benzyl phthalate	85-68-7	100	----
Butylphthalyl butylglycolate (BPBG)	85-70-1	7000	----
Cadmium	7440-43-9	4	kidney
Carbon disulfide	75-15-0	700	developmental effects
Carbon tetrachloride	56-23-5	3	cancer
Chloramben	130-90-4	100	liver
Chlorobenzene	108-90-7	100	liver
Chloroform	67-66-3	60	cancer
2-Chlorophenol	95-57-8	30	developmental effects
Chlorothalonil	1897-45-6	30	cancer

Chemical or Substance	CAS RN	Health Risk Limit µg/L	Toxicologic Endpoint
Chromium III	16065-83-1	20,000	-----
Chromium VI	18540-29-9	100	-----
Cumene (Isopropyl benzene)	98-82-8	300	-----
Cyanide, free	57-12-5	100	endocrine system, nervous system
Dibromochloromethane	124-48-1	10	liver
1,2-Dibromoethane (Ethylene, dibromide, EDB)	106-93-4	0.004	cancer
Dibutyl phthalate	84-74-2	700	-----
Dicamba	1918-00-9	200	development effects
1,2-Dichlorobenzene	95-50-1	600	liver
1,4-Dichlorobenzene (para)	106-46-7	10	cancer
3,3'-Dichlorobenzidine	91-94-1	0.8	cancer
Dichlorodifluoromethane	75-71-8	1000	-----
p,p'-Dichlorodiphenyl dichloroethane (DDD)	72-54-8	1	cancer
p,p'-Dichlorodiphenyldichloroethylene (DDE)	72-55-9	1	cancer
p,p'-Dichlorodiphenytrichloroethane (DDT)	50-29-3	1	cancer
1,1-Dichloroethane	75-34-3	70	kidney
1,2-Dichloroethane	107-06-2	4	cancer
1,2-Dichloroethylene (cis)	156-59-2	70	hematologic system
1,1-Dichloroethylene (Vinylidene chloride)	75-35-4	6	liver
1,2-Dichloroethylene, trans-	156-60-5	100	-----
Dichloromethane (Methylene chloride)	75-09-2	50	cancer
2,4-Dichlorophenol	120-83-2	20	immune system
2,4-Dichlorophenoxyacetic acid (2,4-D)	94-75-7	70	hematologic system, kidney, liver
1,2-Dichloropropane	78-87-5	5	cancer
1,3-Dichloropropene	542-75-6	2	cancer
Di(2-ethylhexyl)phthalate (DEHP)	117-81-7	20	cancer
Diethyl phthalate	84-66-2	6000	------
2,4-Dimethylphenol	105-67-9	100	hematologic system, nervous system
Dimethylphthalate	131-11-3	70,000	kidney
2,4-Dinitrophenol	51-28-5	10	eyes
Disulfoton	298-04-4	0.3	nervous system
Ethylbenzene	100-41-4	700	kidney, liver

Chemical or Substance	CAS RN	Health Risk Limit µg/L	Toxicologic Endpoint
S-Ethyl dipropylthiocarbamate (EPTC)	759-94-4	200	cardiovascular system, nervous system
Ethyl ether	60-29-7	1000	-----
Ethylene glycol	107-21-1	10,000	kidney
Fluoranthene	206-44-0	300	kidney, liver
Fluorene (9H-Fluorene)	86-73-7	300	hematologic system
Formaldehyde	50-00-0	1000	stomach
Heptachlor	76-44-8	0.08	cancer
Heptachlor epoxide	1024-57-3	0.04	cancer
Hexachlorobenzene	118-74-1	0.2	cancer
Hexachlorobutadiene	87-68-3	1	kidney
Hexane (n-hexane)	110-54-3	400	nervous system
Isophorone	78-59-1	100	kidney
Linuron	330-55-2	1	hematologic system
Manganese	7439-96-5	100	nervous system
Methanol	67-56-1	3000	liver, nervous system
2-Methyl-4-chlorophenoxyacetic acid (MCPA)	94-74-6	3	kidney, liver
Methyl ethyl ketone (MEK, 2-butanone)	78-93-3	4000	developmental effects
Methyl isobutyl ketone (MIBK)	108-10-1	300	kidney, liver
2-Methylphenol (o-cresol)	95-48-7	30	nervous system
3-Methylphenol (m-cresol)	108-39-4	30	nervous system
4-Methylphenol (p-cresol)	106-44-5	3	------
Metolachlor	51218-45-2	100	developmental effects
Metribuzin	21087-64-9	200	kidney, liver
Naphthalene	91-20-3	300	------
Nickel, soluble salts	7440-02-0	100	------
Nitrate (as nitrogen)	14797-55-8	10,000	hematologic system
N-Nitrosodiphenylamine	86-30-6	70	cancer
Pentachlorophenol	87-86-5	3	cancer
Phenol	108-95-2	4000	developmental effects
Picloram	1918-02-1	500	liver
Polychlorinated biphenyls (PCBs)	1336-36-3	0.04	cancer
Prometon	1610-18-0	100	------

Chemical or Substance	CAS RN	Health Risk Limit µg/L	Toxicologic Endpoint
Propachlor	1918-16-7	90	------
Pyrene	129-00-0	200	kidney
Selenium	7782-49-2	30	------
Silver	7440-22-4	30	------
Simazine	122-34-9	30	hematologic system
1,1,1,2-Tetrachloroethane	630-20-6	70	kidney, liver
1,1,2,2-Tetrachloroethane	79-34-5	2	cancer
1,1,2,2-Tetrachloroethylene	127-18-4	7	cancer
Thallium salts	7440-28-0	0.6	liver
Tin	7440-31-5	4000	kidney, liver
Toluene	108-88-3	1000	kidney, liver
Toxaphene	8001-35-2	0.3	cancer
1,1,1-Trichloroethane	71-55-6	600	liver
1,1,2-Trichloroethane	79-00-5	3	immune system
1,1,2-Trichloroethylene (TCE)	79-01-6	30	cancer
Trichlorofluoromethane	75-69-4	2000	------
2,4,6-Trichlorophenol	88-06-2	30	cancer
2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)	93-76-5	70	developmental effects, hematologic system
2 (2,4,5-Trichlorophenoxy) propionic acid	93-72-1	60	liver
1,2,3-Trichloropropane	96-18-4	40	kidney, liver
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	200 ,000	------
1,3,5-Trinitrobenzene	99-35-4	0.3	------
Vanadium	7440-62-2	50	------
Vinyl chloride	75-01-4	0.2	cancer
Xylenes (mixture of isomers o, m, p)	1330-20-7	10,000	nervous system
Zinc	7440-66-6	2000	------

The Chemical Abstracts Society Registry Number **(CAS RN)** is a unique number assigned to each substance or chemical by the American Chemical Society.

A **Health Risk Limit** is an exposure value for a concentration of a groundwater contaminant, expressed in micrograms per liter (µg/L), that can be safely consumed daily for a lifetime.

The Toxicologic Endpoint indicates the organ or organ system that is most sensitive to the contaminant. For carcinogens the endpoint is cancer.

(TABLE96.STD)